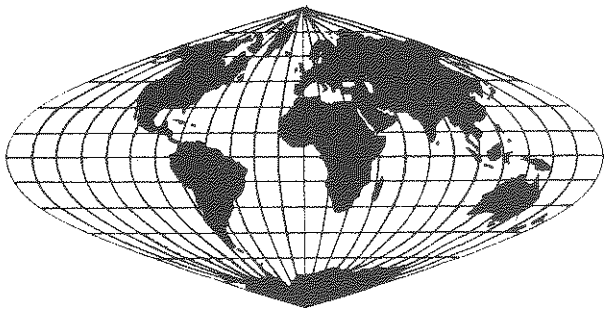
March 1982

A.E. Res. 82-9

CORNELL/INTERNATIONAL AGRICULTURAL ECONOMICS STUDY

PROSPECTS FOR GROWTH IN GRAIN PRODUCTION IN CHINA

Randolph Barker, Daniel G. Sisler, and Beth Rose



DEPARTMENT OF AGRICULTURAL ECONOMICS
New York State College of Agriculture and Life Sciences
A Statutory College of the State University
Cornell University, Ithaca, New York 14853

The Department of Agricultural Economics offers training in International Economics and Development leading to the MPS, MS, and PhD degrees. A component of the Program in International Agriculture of the New York State College of Agriculture and Life Sciences, the course of study and research is flexible and designed to enable students to draw on the expertise of faculty in many disciplines and with wide-ranging international experience, as well as on a core of faculty within the Department who address themselves exclusively to international questions. The geographical focus is on the developing countries of Asia, Africa, and Latin America.

PROSPECTS FOR GROWTH IN GRAIN PRODUCTION IN CHINA*

Randolph Barker, Beth Rose, and Daniel G. Sisler**

China's capacity to increase production and economic efficiency in agriculture in the decade ahead will depend on its ability to adopt appropriate policies and to overcome technical and environmental constraints. With respect to policy, it has been argued that agricultural growth has been retarded by a lack of incentives, and by poor state planning. Insistence on local and regional self-reliance led to an overemphasis on grain production at the expense of cash crops (oilseeds, cotton, soybeans, etc.) and fodder acreage. Many observers believe that recent policy changes will lead to a more rational allocation of resources, but that further improvement could be achieved if China were to adopt price and production planning based on Western concepts of comparative advantage.

The effectiveness of policy changes will depend on the ease with which technical and environmental constraints can be overcome. Is there a backlog of technology that can be readily disseminated, or are further improvements likely to require significant investments in technology development and infrastructure with a long gestation period?

The outlook for grain production is a matter of central concern in this discussion because of the dominant role of grain in the agricultural economy. Approximately 50 percent of gross agricultural product is derived from grain and grain provides close to 90 percent of all calories consumed. It seems that for political and economic reasons China will not increase food grain imports much beyond the current level of about 15 million metric tons or 5 percent of total yearly requirements.[1/]

Until recently there has been little data on which to base judgement regarding the past performance or future potential of Chinese agriculture. Even now available data is spotty and frequently of variable quality, rendering any attempts at quantitative analysis suspect. For a large and climatically diverse country such as China, national aggregates provide no clear understanding of technical constraints and growth potentials. The limitations of data notwithstanding, our discussion in this paper will focus on regional trends in grain production.

Growth in Grain Production Since 1949

Between the late 1950s and the late 1970s grain output grew at about 2.4 percent annually, or slightly faster than population growth. It is clear from reports on conditions in China that per capita production of food grains changed very little if at all during this period. Technical change, policy

---

* The research for this paper has been supported by funds from the Luce Foundation.

** Randolph Barker and Daniel G. Sisler are Professors' of Agricultural Economics, Cornell University; Beth Rose is a Research Assistant in the Department of Agricultural Economics, Cornell University.

measures, and social reforms helped cause uneven growth rates across regions and over time. Important socioeconomic and political movements included land reform (1950-1952), collectivization (1954-1958), Great Leap Forward (1958-1960) Cultural Revolution period (1966-1976), and the four modernizations (1977 to present). Figure 1 illustrates the growth of national grain production against the background of political change. It is virtually impossible to disentangle the effects of political and social reform from other factors, such as weather, on the rate of growth of agricultural production.

Rice is the dominant grain crop, accounting for 45 percent of total unmilled grain production, (Table 1) followed by wheat and corn.[2/] Corn production rose rapidly in the 1970s, slightly surpassing wheat production in some years. While we know the bulk of corn is utilized as a food not a feed grain, we do not know how this proportion is changing over time. However, because of increased emphasis placed on improving diets, we can assume that feed grain utilization is likely to grow.

Long term growth in grain production varies depending on the base year chosen. Differences in estimated annual growth rates for selected time periods are substantial.

1949-1951/1955-1957	6.7%
1955-1957/1977-1979	2.4%
1952-1953/1977-1979	2.8%
1949-1951/1978-1980	3.3%

Between 1949 and 1957 as agriculture recovered from the devastating effects of war, resistence and revolution, production increased very rapidly (6.7%). The 1949-1957 recovery period skews long-term growth rates markedly. For this reason we regard the period 1955-1957 to 1977-1979 as most appropriate for measuring long-term growth.

Policies Affecting Grain Production

Over the past three decades China has maintained low food grain prices and rationed basic necessities so as to ensure a more equitable distribution of supply. While the government subsidized grain prices to consumers, producer prices remained well below international levels and low relative to prices of non-grain crops. An adequate supply of grain was ensured through production planning based on area targets. As a further incentive to grain production, prices for grain sold above the quota were about 50 percent above the quota price. "Squeezing agriculture" with low prices for primary products is a common practice in developing agricultural economies worldwide. Utilization of collective labor for land and water development, and composting of fertilizer, coupled with significant technological advances for the major grain crops, allowed the government to maintain low consumer prices.

Whether shifts in policy following the death of Mao were a consequence solely of political factors, or were caused by a combination of both basic economic forces and politics is a matter of debate. One hypothesis suggests that there were already signs of stagnation in the agricultural sector that

FIGURE 1. TOTAL GRAIN PRODUCTION, CHINA

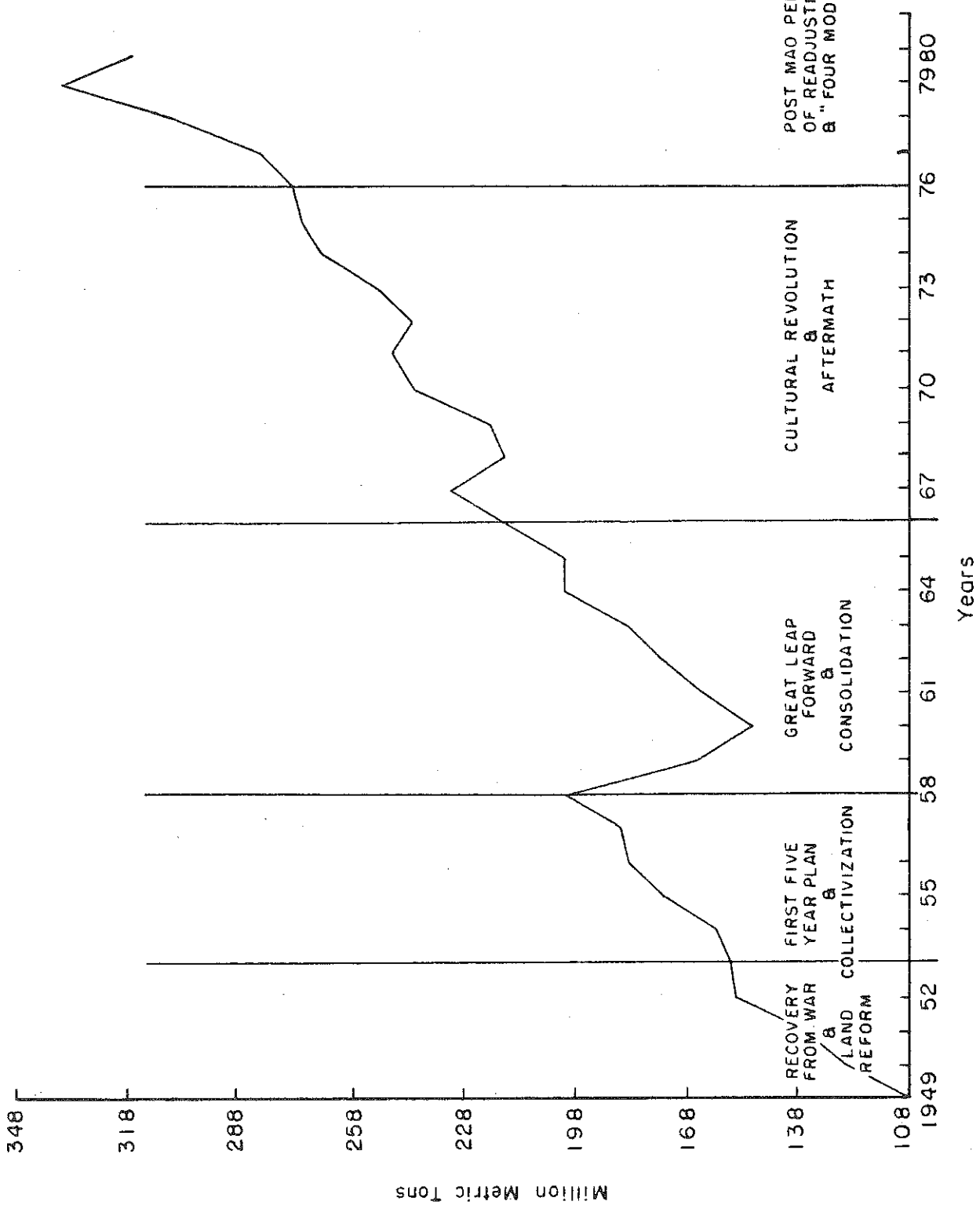


Table 1. Specified Crops as Percentage of Total Food Grain Production.

	1957		1977	
	million tonnes	percent	million tonnes	percent
All grains	195	100	285	100
Rice (unmilled)	87	45	129	45
Wheat	24	12	41	14
Coarse grains and pulses[a/]	52	27	86[b/]	30
Corn	21	11	48	17
Tubers	22[c/]	11	19[c/]	7
Soybeans	10	5	10	4

Source: Anthony Tang and Bruce Stone, "Food Production in the People's Republic of China." Research Report No. 15, International Food Policy Research Institute, May 1980, pp. 157-158.

a/ Includes millet, corn, sorghum, barley, buckwheat, oats, proso-millet, small beans, small green beans, broad beans, peas, and others.

b/ The 1977 estimates for coarse grain and tubers were calculated as a residual. The coarse grain figure appears too low and the tuber figure too high. For example, USDA estimates 1977 coarse grain production at 74.5 million metric tons and 1976 tuber production at 24 million metric tons.

c/ Tubers are valued on a 1-to-4 grain equivalent basis in 1957 and a 1-to-5 basis in 1977.

would have necessitated a change in agricultural policy even without the political upheavel.

Be that as it may, since 1976 there have been significant changes in policy with the future direction of policy still unclear. In 1978, China announced a ten year plan (1975-1985) that was intended to lay the groundwork for achieving success in the "four modernizations" (agriculture, industry, national defense, and science and technology). The 1985 target for grain production was set at 400 million metric tons which implied a growth in output of 4 percent per year over the 10 year period, considerably above the 2.4 percent annual growth rate achieved since 1957.

In December 1978 the Third Plenum of the Chinese Communist Party adopted new policies that gave high priority to agriculture. Changes in agriculture policy have taken three forms: (1) price incentives (quota prices for grain were raised by 20 percent and above quota price was set 50 percent above the quota price), (2) higher allocation of industrial goods and resources to agriculture (e.g. electrical power and chemical fertilizer), and (3) a restructuring of agriculture within the commune to allow for greater resource mobility and flexibility in production decision making.

The likely impact of these incentives on agricultural production as a whole and upon production among various crops and regions is difficult to ascertain. Prices rose, not only for grain crops, but for non-grain crops as well. Inputs such as fertilizer are distributed by the government. Hence, a more favorable fertilizer to crop price ratio does not indicate that fertilizer will be allocated toward those crops and regions where it will give the highest return. Likewise, the degree to which farmers can now choose what they would like to produce is a matter of debate and probably varies considerably from area to area.

In terms of the overall performance of agriculture, the immediate response to the new agricultural strategy was positive. The production of both grain and non-grain crops rose sharply in 1979, partly because of very favorable weather conditions. Record increases occurred despite a decline in total grain acreage, as producers cut back on triple cropping and shifted some land to more profitable non-grain crops like cotton and oilseeds.

Unfavorable weather in north and central China in 1980 resulted in a decline in grain production from the record levels of 1979 and grain imports reached record levels. Despite this, non-grain crop production has continued to rise.

Following the reduced grain harvest of 1980, agricultural policy has swung toward a reemphasis on grain production targets. Policy makers are likely to favor production targets, rather than further increases in producer prices, as a means to insure adequate consumer supplies and to avoid over dependency on world markets. However, the ease with which grain production targets can be met without serious sacrifice of economic efficiency is certainly related to the technical capacity for gains in production.

Regional Growth in Grain Production

Following the work of Buck (1937), it is common to distinguish between north and south China, wheat being the dominant crop in the north and rice in the south. The dividing line is set between the Yangtze and Huai Rivers, and extends westward at approximately 33° north latitude. Historically, the balance of progress in agricultural development has tended to shift back and forth between the drier north and the more humid south.

Agricultural innovation has often been accompanied by shifts in population and political power. For example, a technological revolution in milling in the 8th and 9th century made possible the widespread cultivation of wheat in place of millet. This was followed by the development of the technology of wetland rice culture (8th to the 12th century), that is to say the flooding, puddling, and transplanting of paddy fields that is such a familiar part of the Asian landscape today. This development contributed significantly to population growth in south and central China. It is estimated that in the 17th century rice accounted for 70 percent of all food grains grown. The introduction of food plants (corn, peanuts, sweet potato, and irish potato) from the Americas in the 16th and 17th century, coupled with the growing demand for industrial cash crops, such as cotton and sugarcane, allowed agriculture to expand into hillier and less well watered areas unsuitable for rice. The contribution of rice to total food production declined relative to crops such as wheat and corn. However, the success of intensive cultivation methods in irrigated central and south China helped rice maintain its role as the dominant food grain of China, although by 1930 rice's share of the total had fallen to less than half.[37]

Since 1955 growth in agricultural production has varied over time and among regions. An understanding of this variation is important in making an assessment as to the future potentials for growth. In a country of the size and diversity of China, no regional delineation will accurately combine areas of similar agricultural potential perfectly; however, it is felt that the regional designation adopted here does foster valuable insights when considering the past performance and potential of grain production within China.

We have divided China into eight agricultural regions; I. Northeast, II. North, III. East, IV. Central, V. South, VI. Southwest, VII. Sichuan, and VIII. Northwest. Figure 2 delineates the provincial boundaries of the eight agricultural regions. In general, we have followed the designations, used by western agriculturalists since Buck in 1937. An exception is the province of Sichuan shown as a separate region (VII). We felt that agriculture within Sichuan was unique, and could not logically be combined with any adjacent regions.

Important agro-climatic characteristics of each region, with the exception of Region VIII, are summarized in Table 2. The northwest is excluded from this table because the agro-climate of this vast area is too varied.

FIGURE 2. AGRICULTURAL REGIONS OF CHINA

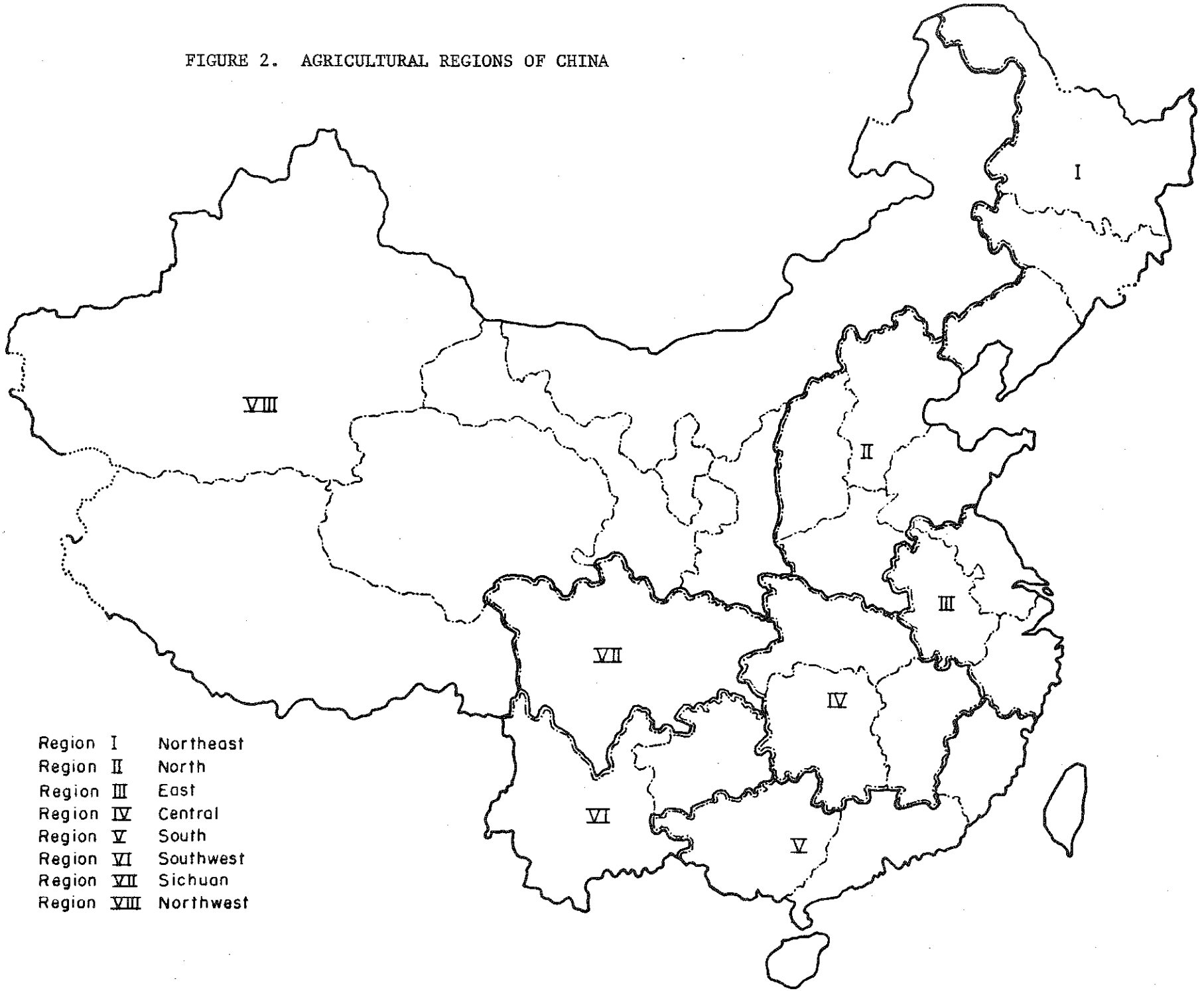


Table 2. Selected Agro-climatic Characteristics of Seven Agricultural Regions of China.

Region		Cropping index	Frost free period (days)	Average July temperature (C degrees)	Average January temperature (C degrees)	Precipitation (mm/yr)	Cultivated land irrigated percent *	Major crops
I.	Northeast	100	140 to 180	26 to 28	-13 to -23	500 to 700	14	Corn, millets, soybeans
II.	North	110	210 to 250	26 to 28	-4 to -7	600 to 800	53	Wheat, corn, soybeans
III.	East	170	230 to 250	25 to 27	3 to 5	700 to 1000	68	Rice, cotton, wheat
IV.	Central	180	240 to 320	27 to 29	7 to 10	700 to 1500	73	Rice, wheat, soybeans, cotton
V.	South	180	340 to 365	27 to 28	14 to 15	1500 to 2000	73	Rice, tubers, corn
VI.	Southwest	145	260 to 300	21 to 25	5 to 9	1000 to 1200	42	Rice, tubers, corn, cotton
VII.	Sichuan	170	290 to 340	27 to 29	6 to 8	800 to 1000	50	Rice, corn, tubers

Sources: C. Chen and M. Y. Nuttonson, The Agricultural Regions of China (Washington, D.C.: American Institute of Crop Ecology, 1969).

T. R. Tregear, An Economic Geography of China (London: Butterworths, 1970).
A.Y.M. Yao, "Characteristics and Probabilities of Precipitation in China" USDA Environmental Services Administration, Technical Report No. EDS8.

*Percent irrigated calculated from data in Zhongguo Nongye Dili Zonglun (General Treatise on Agricultural Geography) translation appearing in JPRS No. 78034, May 8, 1981.

Table 3. Annual Growth in Total Grain Production by Region, PRC.[a/]

Region[b/]		1955-1957 (million tonnes)	1977-1979 (million tonnes)	1957-1979 (percent)
I.	Northeast	17.1	33.3	3.1
II.	North	37.7	68.5[c/]	2.8
III.	East	31.4	52.7	2.4
IV.	Central	27.7	49.6	2.7
V.	South	21.6	34.3	2.1
VI.	Southwest	10.7	14.2	1.3
VII.	Sichuan	21.9	30.2	1.5
VIII.	Northwest	15.6[d/]	22.4[e/]	1.7
TOTAL-all regions		183.7	305.2	2.3
USDA-TOTAL GRAIN		180.8	306.5	2.4

Sources: "Provincial Agricultural Statistics for Communist China," Committee on the Economy of China, Social Science Research Council, Ithaca, New York, 1969, and Francis Tuan, "Provincial Total Grain Production 1969-1979," Research Notes on Chinese Agriculture No. 2, USDA, Economics and Statistics Service, International Economics Division, Asia Branch People's Republic of China section, 1981.

a/ Growth percent calculated with an average of 1955-1957 as a beginning period and an average of 1977-1979 as an end period.

b/ There are several problems in the raw data that may affect our regional growth percents to varying degrees. Administrative boundary changes between provinces may have altered results slightly. Tuan's report assumes that provinces have made adjustments themselves. There is also a possibility that 1979 production includes private plot production. This could account for as much as five million metric tons. For 16 cases data were not available and an estimate was made based on the best information available. The problem of missing data was most serious in the southwest and northwest rendering those growth rates suspect.

c/ Tianjin municipality was created in 1967 and further enlarged in 1973 for Hebei province. This should not alter regional growth as no area was moved outside the region.

d/ Xizang and Ningxia were not included.

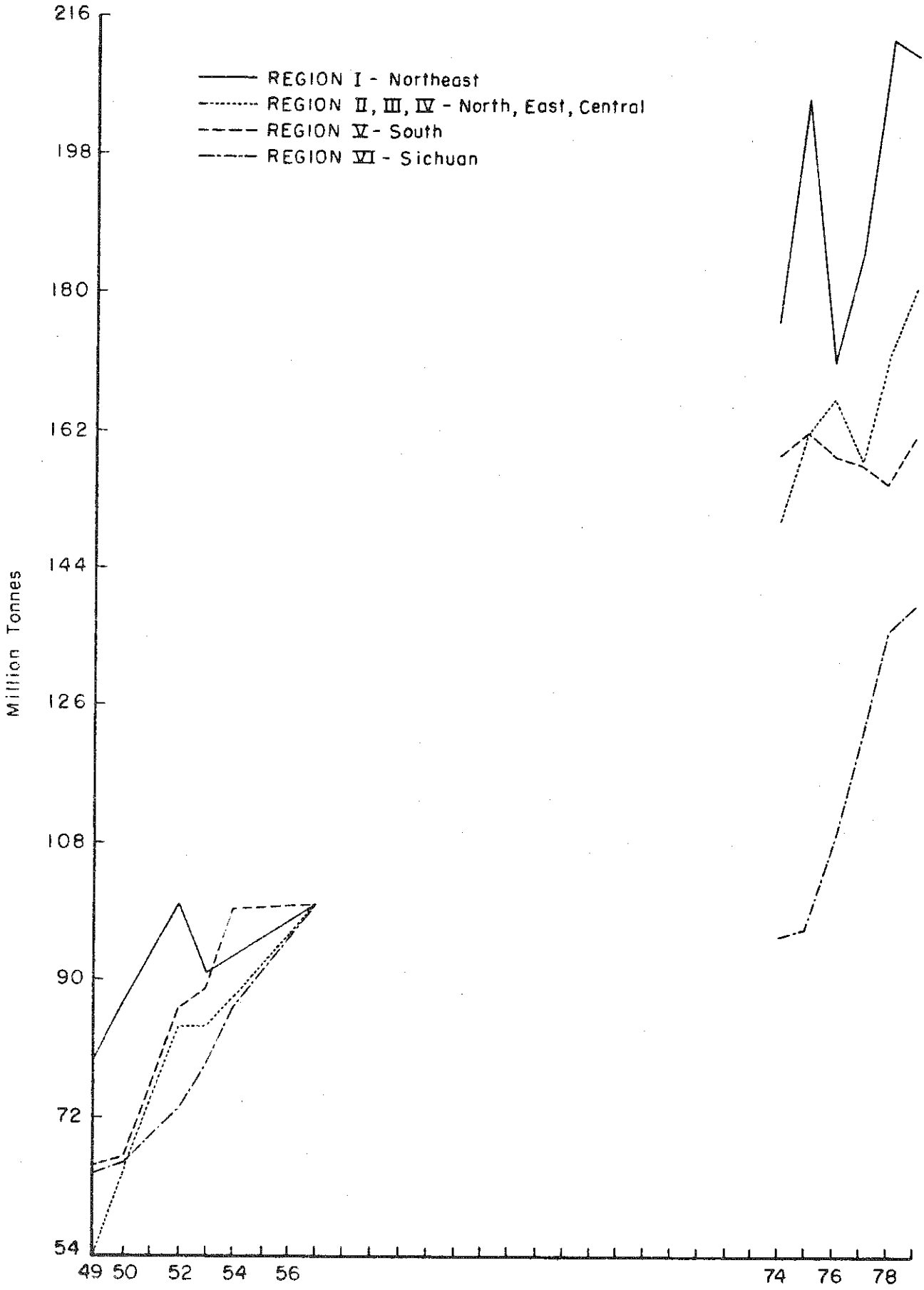
e/ Ningxia not included.

Table 4. Annual Growth in Total Grain Output for Selected Provinces, PRC 1955-1957 and 1977-1979.

Province	Region	Average		Annual growth (percent)
		1955-1957	1977-1979	
		(million tonnes)		
Heilongjiang	Northeast	6.4	13.9	3.6
Shanxi	North	3.6	7.3	3.3
Hebei	North	8.7	16.7	3.0
Hunan	Central	10.9	20.8	3.0
Guangxi	South	5.7	10.8	2.9
Jilin	North	4.7	8.8	2.9
Xinjiang	Northwest	1.9	3.6	2.9
Zhejiang	East	7.7	13.9	2.7
Jiangxi	Central	6.5	11.7	2.7
Jiangsu	East	12.2	21.6	2.6
Shandong	North	12.6	22.1	2.6
Liaoning	Northeast	6.1	10.6	2.5
Fujian	South	4.2	7.0	2.3
Hubei	Central	10.3	17.1	2.3
Henan	North	12.0	19.5	2.2
Shaanxi	Northwest	4.8	7.6	2.1
Neimonggol	Northwest	3.4	5.1	1.9
Qinghai	Northwest	0.6	0.9	1.9
Yunnan	Southwest	5.9	8.4	1.6
Anhui	East	10.5	14.7	1.5
Guangdong	South	11.7	16.4	1.5
Sichuan	Sichuan	21.9	30.2	1.5
Gansu	Northwest	4.8	4.8	0

Source: See Table 3, Source.

FIGURE 3. INDEX PRC TOTAL GRAIN PRODUCTION BY REGION, 1957=100
(SOUTHWEST and NORTHWEST not included)



In calculating regional and national growth rates, we have relied principally on official production estimates compiled by Tuan (USDA, 1981)[4] for the 1970s and on provincial information gathered by the Committee on the Economy of China, Social Science Research Councils[5] for the 1950s. From 1957 until the middle 1970s almost no official provincial estimates were released, so that we have chosen to estimate growth rates using the years 1955-57 and 1977-79 (Table 1). In addition, these years were not marked by any major political or social upheaval. Regional estimates were obtained by summing provincial estimates within the respective regions.

Table 3 presents annual growth rates in grain production for China in total and for the eight regions.[6] The growth rate in grain production has varied widely from 3.1 percent per annum in northeast China, to 1.3 percent per annum in southwest China. Regions I to IV have grown much more rapidly than regions V to VIII. There is, of course, considerable variation in growth rates among provinces within regions, as is illustrated in Table 4 where provinces have been ranked by annual growth rate. Guangxi in South China has shown remarkable growth compared to its neighboring provinces. Conversely, Anhui's growth rate (III) is extremely low compared to its neighbors in east China.

In Figure 3 we have plotted an index of growth for selected regions for the period 1949-1957 and 1974-1979. The Southwest (VI) and the Northwest (VIII) have been excluded due to data problems (Table 3, Footnote b). Regions II, III, and IV evidenced similar growth patterns and have been combined. The region of most rapid growth, the Northeast, is also the region of greatest variability in year-to-year production. There was apparently no growth in grain production in Sichuan and Southwest China between 1957 and the mid 1970s. However, growth has been rapid in the last five years. Between 1957 and 1975 the annual growth rate for south China was equal to that for north, east, and central China, but production seems to have stagnated since.

Fluctuations in annual grain production are extremely important. Uncertainty induces stresses on available food supply and places additional burdens on transportation, storage, and imports. Many observers of Chinese agriculture have concluded that total grain production is relatively stable, with less year-to-year swings than in many other important grain producing nations. This observation is reinforced by the fact that over 45 percent of Chinese grain acreage (about 2/3 of production) is irrigated, thereby lessening uncertainty associated with erratic rainfall patterns. We have computed yearly deviations from trend for China as a whole and for seven regions (omitting the Northwest) from 1957 to 1979. The regional estimates were based on only 13 years of data in this period. The average yearly deviations from the value predicted by a fitted line amounted to about 5 percent of average grain production. The Northeast (I) showed the highest year-to-year fluctuations during the 1970s. Grain production dropped sharply in Sichuan and the Southwest in 1974 which was otherwise a good weather year, and in the Northeast in 1972 and 1976 which were poor weather years country-wide.

The government procures very little grain for shipment to deficit rural areas. Thus, trends in grain production can be presumed to have an influence on regional consumption. Estimates of per capita unmilled grain production are shown for 1955-1957 and 1977-1979 in Table 5. The recovery rate for milled rice is typically about 72 percent which is lower than wheat (85%), or corn

Table 5. Per Capita Production of Rough Grain, kg/capita/year, 1955-1957 and 1977-1979.

Region		1955-1957	1977-1979	Percent change
I.	Northeast	332	347	4.5
II.	North	225	294	30.7
III.	East	283	342	20.8
IV.	Central	324	384	18.5
V.	South	300	300	0.0
VI.	Southwest	297	246	-20.7
VII.	Sichuan	303	311	2.6
VIII.	Northwest	326[a/]	306[b/]	-6.5
TOTAL		285	320	12.3

Source: Production: See Sources, Table 3.
Population: John Aird, "Recent Population Figures," China Quarterly, no. 7, 1978, and John Jowett, "China: The Provincial Distribution of Population," China Quarterly, March 1980.

a/ Ningxia and Xizang omitted
b/ Ningxia omitted.

(92%). Hence, in relative terms the predominantly rice eating regions of southern China have a lower per capita availability than is suggested by the data in Table 5. Those regions with the lowest per capita production in 1955-1957, the North and the East, showed the largest gains over the last two decades. Regions I to IV all showed significant increases, while Regions V to VIII showed little increase (or in the case of VI, a decline) over the period.

Crop Yields

The recent decline in some regions in the intensity of cropping - e.g. shifts from triple to double cropping - make it appear that the limit of land intensification has been reached. As a consequence, future production gains will be determined almost entirely by increases in single crop yields. There is very little reliable data on crop yields even at the national level. For example, in the most widely used series from the U.S. Department of Agriculture it is impossible to compare or link yield estimates up to 1976 with those after 1976. National yield growth for major cereal grains from 1955-1957 to 1974-1976 are as follows:

	China	India	U.S.
rice	1.6	1.3	2.0
wheat	2.8	3.1	1.9
corn	2.3	1.6	3.3

The most notable technological achievements have been made in the areas of rice and wheat. This includes the introduction of modern fertilizer responsive varieties in the 1960s, and the development of the world's first F^1 hybrid rices in the 1970s. The slow growth in rice yields, despite these achievements, may be explained in part by overzealous efforts on the part of codres to intensify production through the expansion of triple cropping.

On a regional level crop yield and acreage data is sparse and sometimes unreliable. We can make some assessment of regional yields by looking at climatic analogues. Climatically the lower Yangtze River Valley is similar to southern Japan and Guangdong to Taiwan. As best we can determine from the information available, rice yield levels in these two regions are similar to those achieved in Japan and Taiwan 15 to 20 years ago. As we look back on the development experience of Japan and Taiwan, we are reminded of the substantial incentives, including the raising of rice prices well above the world market, that brought rice yields in these two countries to their current high plateau.

Both the level of wheat yields and the rate of increase in yield are almost identical with those of India and Pakistan. Significant yield gains have been achieved through the extensive use of modern varieties and fertilizers and the expansion of irrigated area. China's largest wheat area is the North China Plain, and this area accounts for almost three-quarters of total production. The growth of irrigation in this area, as in the Indo-Gangetic Plain, has occurred largely through the use of tubewells. Currently more than 80 percent of the wheat in this area is said to be irrigated, while the 1950 level was probably less than 20 percent. Despite this progress, the national wheat yield is currently only 2 tons per hectare. In Mexico and

Egypt, where most of the wheat production is also under irrigation, yields are approaching 3.5 tons per hectare.

As noted previously, corn production has risen significantly in China over the past three decades. Between 1957 and 1977 it rose from 11 to 17 percent of total production. Unlike rice and wheat, a substantial portion of the increase in production was due to area expansion, as higher yielding corn was substituted for lower yielding sorghum (gaoliang) and millets, principally in north and northeast China. Corn yields have improved significantly over this period from 1.5 to 2.5 tons per hectare, but even today are considerably less than half those of the United States (6 tons per hectare).

Inputs

The principal sources of future yield growth in grain production can be identified as: (1) varietal improvement, (2) fertilizer, and (3) irrigation. Varietal improvement depends on research, or on the transfer of technology. Research is needed to develop new varieties of grain with greater yield potential and resistance to insects and diseases, and to develop new cultural and management practices. The potential does exist for borrowing from the experience of others. However, new agricultural technology must be adapted, not only to local climatic conditions, but also to the particular factor endowments and socioeconomic conditions of China. For example, historically it has been difficult to introduce new foreign plant varieties to China, because the intensive crop rotations demanded an early maturity not found in most exotic plant materials.

It would appear that in the recent past research priority has been given to rice, followed by wheat, with corn and other grain crops getting much less attention. It is difficult to assess the degree to which the Cultural Revolution and its aftermath may have set back agricultural research, and how long it will take to overcome this deficiency. It is equally difficult to judge China's capacity to transfer appropriate technology from other parts of the world. China did import significant amounts of Mexican wheat seed in the 1970s. Mexican wheat and Chinese-Mexican crosses are being grown on approximately a quarter of the total wheat area, principally in the Northeast and south of the Yangtze River. At present the most active program of scientific exchange and manpower training involves extensive interaction with the International Rice Research Institute in the Philippines.

In the initial steps to modernize agriculture following independence, principal emphasis was placed on organic compost as the primary source of plant nutrients. With the development of small-scale rural industries following the Great Leap Forward, ammonium bicarbonate became an important source of nitrogen fertilizer. The importation of thirteen modern urea plants in the 1970s led to a near doubling in the production of chemical fertilizer (5.5 million tons nutrient weight in 1975 to 10.7 million tons in 1979). The national fertilizer application rate now exceeds 100 kilograms per cultivated hectare. However, over half of fertilizer by nutrient weight is still supplied by organic materials, an extremely large share compared with other developing countries.

Although the Chinese have emphasized the production of nitrogen fertilizer many soils, particularly those in the south, are deficient in phos-

phorus and potassium. Increased application of these elements could boost stagnant rice yields.

The rate of fertilizer application per hectare will continue to increase. China must expand domestic capacity of modern fertilizer plants, not only to meet this growing demand, but also to replace ammonium bicarbonate plants and organic fertilizers that could become increasingly obsolete because of the high opportunity cost of land and labor used in their production. The ten year plan has set a target of one large chemical fertilizer plant for each province and autonomous region plus an additional ten plants (for a total of 39). However, it is unlikely this target will be met by 1985. In any event, China will certainly encounter many difficulties in changing the structure and scale of fertilizer production so as to meet ever growing demands.

The third major technical constraint in the expansion of grain production is water availability. Here again, as in the case of fertilizer, there has been a shift away from local self-reliance. The national government has taken increasing responsibility for decision making in the construction and improvement of irrigation facilities. Emphasis has moved from small-scale projects under county, commune, and brigade control, to more capital intensive and large-scale endeavors. This is a reflection of the fact that opportunities for development of small-scale systems have been almost fully exploited. Further expansion may require the development of major projects with relatively long gestation periods. There is a growing reluctance to exploit local labor for the construction of projects of this type. Although the PRC is still considering some large-scale water management projects, many prominent scientists suggest more research, particularly environmental investigation, is necessary before actual building commences, and current capital constraints make it difficult for China to proceed.

A major objective of the proposed irrigation projects is to provide northern China with more water. Water is the major constraint to increased agricultural production in this area. Expansion of irrigation in the North China Plain led to rapid growth in wheat production and yields in the last two decades. However, there have been major salinity problems associated with poor drainage in the development of these water resources, necessitating the withdrawal of as much as 2 million hectares of land from agricultural production.

The kinds of problems that have been outlined above are by no means insurmountable. However, it does suggest the need, not only for appropriate policies, but also for skillful management at all levels of planning and production. Shortage of management skills would seem to be a major constraint to agricultural production in the short run.

Conclusions

Grain occupies a dominant position in the Chinese agricultural economy. What happens in the grain sector will have a critical effect on the rate of agricultural and economic development in the future. If production slows and imports increase markedly, then resources will have to be diverted away from potentially more profitable activities to boost production.

The growth in grain production over the past two decades has been slightly above the rate of growth of population and close to the average of the performance of other developing countries. However, there is a general consensus that overemphasis on local grain self-sufficiency led to a sacrifice in efficiency.

Recent policy changes have resulted in significantly higher price incentives to grain producers, and in more flexibility in decision making at the local level regarding the choice of crops and crop rotations. Despite the higher grain prices, there has been a shift of some land and resources to more profitable alternatives. As a consequence of the reduced grain harvest of 1980, the Chinese are finding it necessary to reevaluate their policies.

It is our contention that, in spite of these policy shifts due largely to short run weather effects, the Chinese will face serious technical and environmental constraints to increased grain production in the immediate future. These constraints are best viewed in the context of specific crops and regions.

Over the longer period, the prospects for growth in wheat and corn production appear to be more favorable than for rice. The consequence of this must be evaluated in the context of shifts in demand for grain, which are as difficult to forecast as shifts in supply. The population growth rate will probably continue to decline. At the same time, if incomes rise, there will probably be an increasing demand for livestock products and consequently feed grains, particularly corn. Food grains can be supplied by either domestic production or the export market. Furthermore, there is ample opportunity for substitution of wheat for rice in food grain consumption.

In summary, the question is not whether grain production can grow in the future, but whether needed supplies can be obtained without slowing the rate of growth of the rest of the economy. The efficient growth of domestic grain production in a severely overpopulated country depends on the development of new technology and infrastructure. Underinvestment in scientific manpower and agricultural infrastructure over the past two decades will make it more difficult to overcome the technical constraints to growth in grain production in the near future.

NOTES

1. According to USDA estimates total grain imports for 1980/81 reached 14.6 million metric tons.

2. The current Chinese definition of grain covers a wide range of plant, products that include corn, wheat, rice, oats, barley, buckwheat, sorghum, millets, etc..., soybeans, tubers (irish and sweet), and pulses (field beans, fields peas, etc...). Tubers are currently valued on a 1 to 5 grain equivalent basis.

3. For a more detailed discussion of the above issues see Ping-ti Ho, "The Introduction of American Food Plants into China," American Anthropologists 57 (1955): 191-199, and Ping-ti Ho, "Early Ripening Rice in Chinese History," Economic History Review 9 (1956): 200-218.

4. Francis C. Tuan, "PRC Provincial Total Grain Production, 1969-1979," Research Notes on Chinese Agriculture No. 2, USDA Economics and Statistics Service (January 1981).

5. Committee on the Economy of China, Social Science Research Council, "Provincial Agricultural Statistics for Communist China" (Ithaca, N.Y.: 1969).

6. Although we have relied on official provincial information in the calculation of the 1955-57 through 1977-79 growth rates, the tenousness of this data cannot be overemphasized. Provincial estimates are based on a combination of scattered official estimates, and on government statements regarding the level of production relative to a previous year. Information is almost totally missing from 1958 until the 1970s. Much more data is available for the latter part of the 1970s. However, even at the national, there is a great deal of uncertainty about estimates. For example, the USDA points out there is an inconsistency in their estimates for the years up to 1976 and following 1976.

READINGS

The most comprehensive data for provincial grain production are found in Francis C. Tuan, "PRC Provincial Total Grain Production, 1969-79." Research Notes on Chinese Agriculture No. 2, USDA, Economics and Statistics Service, January 1981. The most detailed regional description of Chinese agriculture, although increasingly out of date, is John Lossing Buck, Land Utilization in China, Chicago: University of Chicago Press, 1937.

For an historical perspective on the early development of grain production in China see Mark Elvin, The Pattern of China's Past, "The Revolution in Farming," Chapter 9, Palo Alto: Stanford University Press, 1973 and Ping-ti Ho, "Early Ripening Rice in Chinese History," The Economic History Review, 9(1956):200-218.

General literature for grain production is more extensive for rice and wheat than for corn and other grain crops. A very detailed study of rice cultivation was completed in China in the early 1960s and recently has been translated into English. Ting Ying, Cultivation of Chinese Paddy Rice, U.S. Joint Publication Research Service, June 1, 1979 (JPRS #73599). Other useful reports include National Academy of Sciences, Committee on Scholarly Communication with the People's Republic of China, Wheat in the People's Republic of China, CSCPRC #6, Washington, D.C. 1977 and Chinese Academy of Sciences and International Rice Research Institute, "Proceedings of International Rice Research Workshop," Guangzhou, People's Republic of China, October 1979, Los Banos, Philippines: International Rice Research Institute, 1980.

In addition there are many useful materials in Chinese. Zhongguo Nongye Dili Zonglun (Treatise on the Agricultural Geography of China) (Beijing: Kexue Chuban She, 1980) is a good general work.

INTERNATIONAL AGRICULTURAL ECONOMICS STUDY SERIES

1. Dwight A. Jurey, "Agriculture Among the Lopit Latuke in Eastern Equatoria, Sudan," December 1981. (A.E. Research 81-30)

2. Marco Ferroni, "Large-Sample Monitoring of Household Expenditure and Food Consumption in Partial Subsistence Economies: A Methodological Note," January 1982. (A.E. Research 82-2)

3. Marco Ferroni, "The Nature and Extent of Nutritional Deficiencies in the Peruvian Andes," January 1982 (A.E. Research 82-4)

4. Iqbal Hussain, "The Scope for Increasing Labor Absorption in Pakistan Agriculture," January 1982. (A.E. Research 82-6)

5. Peter T. Ewell and Thomas T. Poleman, "Uxpanapa: Resettlement and Agricultural Development in the Mexican Tropics," January 1982. (A.E. Research 82-7)

6. Prasadranjan Ray, "Whither Indian Tea?" January 1982. (A.E. Research 82-8)

7. Randolph Barker, Beth Rose, and Daniel G. Sisler, "Prospects for Growth in Grain Production in China," March 1982. (A.E. Research 82-9)